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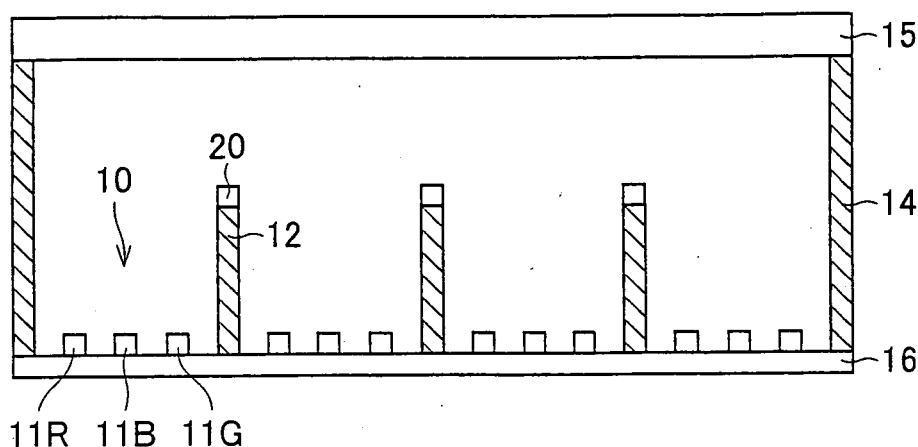
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(54) **ILLUMINATING DEVICE AND LIQUID CRYSTAL DISPLAY**

(57) An illumination device (1) comprises a plurality of light source blocks (10) defined by a first partition wall (12) and a second partition wall (14), the light source blocks (10) being provided with LEDs (11). The illumination device (1) is capable of adjusting a luminance of each of the plurality of light source blocks (10). A projec-

tion section (20) to diffuse the light is provided on a vertex of the first partition wall (12). This way, it is possible to inhibit a luminance irregularity and a color irregularity occurring between illumination areas when adjusting the respective luminance in each of the plurality of illumination areas.

**FIG. 1**



## Description

### Technical Field

**[0001]** The present invention relates to a backlight comprising a plurality of light sources and to a liquid crystal display device provided with the backlight.

### Background Art

**[0002]** Liquid crystal display devices are characterized, among other aspects, by thinness, low electricity consumption and high definition, and are getting more and more popular in the field of televisions, which conventionally use mainly cathode ray tubes (CRT), as the development of production methods of the liquid crystal display devices makes it possible to produce bigger screens. However, it is a problem that the contrast (dynamic range) of an image displayed by a liquid crystal display device is low compared to an image of a CRT. As a result, in recent years a lot of efforts have been made to develop a technology allowing to increase image quality through an increase of the contrast of the liquid crystal display device.

**[0003]** For example, Patent Literature 1 discloses a backlight comprising a plurality of illumination areas whose luminance is controllable independently. Further, a liquid crystal display device disclosed in Patent Literature 1 virtually comprises a plurality of display areas corresponding to the illumination areas of the backlight, respectively. The luminance of the illumination light of each illumination area of the backlight is controlled according to how bright an image displayed in the corresponding display area of the liquid crystal display device is. In other words, with the configuration disclosed in Patent Literature 1, in the illumination area corresponding to the display area in which a bright image is displayed, the luminance of the illumination light is controlled at a high level, while in the illumination area corresponding to the display area in which a dark image is displayed, the luminance of the illumination light is controlled at a low level. This allows for an expansion of the dynamic range, thus making it possible to achieve a liquid crystal display device capable of displaying a high-contrast image.

**[0004]** Patent Literature 1 presents the use of a direct backlight 100 comprising a plurality of light sources 101 isolated in each illumination area by the partition wall 102, as shown in Fig. 8, as a backlight comprising a plurality of illumination areas. The light source 101 is a cold-cathode fluorescent ray tube, and a white LED (not shown on the drawings) used for luminance adjustment is disposed under the light source 101. Due to the white LED, the luminance ratio of the illumination light in adjoining luminous area is increased.

**[0005]** Further, according to Patent Literature 1, because each illumination area is divided by the partition wall 102, the mutual interferences between adjoining illumination areas can be prevented, and it is possible to

obtain an image with a higher definition.

**[0006]** However, the backlight 100 shown in Fig. 8 uses for each illumination area the light source 101 and the white LED. Because the light source 101 and the white LED have different wavelengths, a colored contour (color irregularity) occurs on the diffusion plate in the vicinity of the partition wall 102 when turning on a illumination area and turning off another illumination area adjoining to the lighted illumination area.

### Citation List

### Patent Literature

15 **[0007]**

Japanese Patent Application Publication, Tokukai, No. 2002-99250 (Publication Date: April 5, 2002)

20 Summary of Invention

### Technical problem

**[0008]** The present invention is accomplished in view of the above-described problems. An object of the present invention is to provide an illumination device capable of conducting a luminance adjustment for each illumination area, wherein a luminance irregularity and a color irregularity are inhibited.

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### Solution to Problem

**[0009]** In order to solve the problem described above, an illumination device in accordance with the present invention is provided with a plurality of illumination areas delimited by a partition wall, wherein the illumination areas are provided with a light source, the plurality of illumination areas are able to adjust individually a luminance of each illumination area, and a diffusion section to diffuse light is provided at the vertex of the partition wall.

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### Advantageous Effects of Invention

**[0010]** With the above configuration, the light emitted from the light source of the illumination area is diffused by the diffusion section provided at the vertex of the partition wall. As a result, it is possible to inhibit a luminance irregularity when adjusting the luminance in each adjoining illumination area.

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**[0011]** Further, when providing the diffusion section at the vertex of the partition wall, it is not necessary to increase the width of the partition wall in order to add the diffusion section. Further, by providing the diffusion section at the vertex of the partition wall, it is possible to dispose paths (i.e. light paths) of the light emitted from the adjoining illumination areas symmetrically with respect to the vertex of the partition wall. As a result, compared to a configuration in which the diffusion section is

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not provided at the vertex of the partition wall, it is possible to provide the diffusion section efficiently and to inhibit efficiently a luminance irregularity caused when adjusting the luminance in each adjoining illumination area.

#### Brief Description of Drawings

#### [0012]

Fig. 1

Fig. 1 is a cross-sectional view, taken along the A-A' line shown in Fig. 2, of a relevant part of an illumination device in accordance with an embodiment of the present invention.

Fig. 2

Fig. 2 is a plan view of a relevant part of a structure of the illumination device in accordance with the embodiment of the present invention.

Fig. 3

(a) of Fig. 3 is a plan view of a projection section of the illumination device in accordance with an embodiment of the present invention. (b) of Fig. 3 is a side view of the projection section shown in (a) of Fig. 3. (c) of Fig. 3 is a perspective view of the projection section shown in (a) of Fig. 3.

Fig. 4

(a) of Fig. 4 is a plan view of a projection section of the illumination device in accordance with an embodiment of the present invention. (b) of Fig. 4 is a side view of the projection section shown in (a) of Fig. 4. (c) of Fig. 4 is a perspective view of the projection section shown in (a) of Fig. 4.

Fig. 5

(a) of Fig. 5 is a plan view of a projection section of the illumination device in accordance with an embodiment of the present invention. (b) of Fig. 5 is a side view of the projection section shown in (a) of Fig. 5. (c) of Fig. 5 is a perspective view of the projection section shown in (a) of Fig. 5.

Fig. 6

(a) of Fig. 6 is a plan view of a projection section of the illumination device in accordance with an embodiment of the present invention. (b) of Fig. 6 is a side view of the projection section shown in (a) of Fig. 6. (c) of Fig. 6 is a perspective view of the projection section shown in (a) of Fig. 6.

Fig. 7

(a) of Fig. 7 is a plan view of a diffusion section of the illumination device in accordance with an

embodiment of the present invention. (b) of Fig. 7 is a side view of the diffusion section shown in (a) of Fig. 7. (c) of Fig. 7 is a perspective view of the diffusion section shown in (a) of Fig. 7.

Fig. 8

Fig. 8 is a perspective view of a structure of a relevant part of an illumination device in accordance with a conventional art.

#### Reference list

#### [0013]

- 1 illumination device
- 10 light source block (illumination area)
- 11 LEDs (light source)
- 11B LED (light source)
- 11G LED (light source)
- 11 R LED (light source)
- 12 first partition wall
- 14 second partition wall
- 15 diffusion plate (transparent member)
- 16 reflection sheet
- 20 projection section (diffusion section)
- 21 projection section (diffusion section)
- 22 projection section (diffusion section)
- 23 projection section (diffusion section)
- 24 diffusion section

#### Description of Embodiments

#### First embodiment

[0014] One embodiment of the present invention is described below with reference to the attached drawings Figs. 1 to (a), (b) and (c) of 3.

[0015] Following is an explanation, referring to Figs. 1 and 2, of an illumination device 1 in accordance with an embodiment of the present invention.

[0016] Fig. 2 is a plan view of the illumination device 1 in accordance with an embodiment of the present invention. Fig. 1 is a cross-sectional view of Fig. 2 along the line A-A'.

[0017] As shown in Fig. 2, light source blocks 10 (illumination areas), on which LEDs 11 ("LED" standing for light-emitting diode) as described below are mounted, are provided in a matrix disposition on the illumination device 1. Further, between the light source blocks 10, a first partition wall 12, which has a projection section 20 (to be described below) thereon, is formed. The first partition walls 12 are provided in a lattice-like form over the illumination device 1. In addition, around the illumination device 1, a second partition wall 14, higher than the first partition wall 12, is formed. The area corresponding to the light source block 10 is defined by the first partition wall, or is defined by the first partition wall and the second partition wall.

**[0018]** Further, as shown in Fig. 1, a reflection sheet 16 to reflect light is provided on a bottom face of the illumination device 1. In other words, the LEDs 11, the first partition wall 12 and the second partition wall 14 are formed on the surface of the reflection sheet 16. Additionally, the diffusion plate 15 (transparent member), which faces the reflection sheet 16, is supported by the second partition wall 14 and covers a surface of each light source block 10. The diffusion section 15 diffuses the light emitted from each light source block 10, thereby causing the illumination device 1 to serve as a surface light source for emitting a uniform quantity of light.

**[0019]** The LEDs 11 provided in each light source block 10 include, as a plurality of light sources with different wavelengths, a LED 11R emitting a red light, a LED 11G emitting a green light and a LED 11B emitting a blue light. Substantially at a center of the light source block 10, a single LED 11B is mounted. Additionally, two LEDs 11R and two LEDs 11G are mounted in the light source block 10 in a point symmetry substantially with respect to the LED 11B. In other words, the LED 11B, the LEDs 11R and the LEDs 11G are mounted in matrix in each light source block 10.

**[0020]** Because the LED 11B, the LEDs 11R and the LEDs 11G are mounted in each light source block 10 in this way, it is possible to widen a luminance ratio between adjoining light source blocks 10. Further, because the LED 11B, the LEDs 11R and the LEDs 11G are disposed in matrix in each light source block 10, it is possible to emit light of a uniform luminance from each light source block 10.

**[0021]** In the present embodiment, the light source blocks 10 are disposed with 28 mm pitches, and the LED 11B, the LEDs 11R and the LEDs 11G are each disposed with intervals of 7 mm.

**[0022]** Further, the "on" (lighting) or "off" (not lighting) control of the LED 11B, the LEDs 11R and the LEDs 11G mounted in each light source block 10 is conducted separately in each light source block 10. As an alternative, instead of the LEDs 11, a white LED emitting a white light may be used as the light source in each light source block 10.

**[0023]** The projection section 20, which will be described in details later, is formed on a face of the first partition wall facing the diffusion plate 15 (hereafter referred to, out of convenience, as an upper face of a vertex). In addition, a combined height of the projection section and of the first partition wall is lower than a height of the second partition wall. In other words, a space is provided between the projection section 20 and the diffusion plate 15.

**[0024]** In the present embodiment, a combined height of the projection section 20 and of the first partition wall 12 is 10 mm, while the height of the second partition wall 14 is 25 mm. As a result, the diffusion plate 15 is disposed 25 mm away from the surface of the reflection sheet 16 on which the LEDs 11 are disposed. In addition, the interval between the diffusion plate 15 and the projection

section 20 is 10 mm.

**[0025]** Because a space is provided between the diffusion plate 15 and the projection section 20 in this way, when adjoining light source blocks 10 are turned on concurrently, their respective light become mixed in the space. As a result, it is possible to prevent the area corresponding to the first partition wall 12 from becoming dark. In other words, it is possible to prevent luminance irregularities that would occur when adjoining light source blocks are lighted together. This makes it possible to achieve uniform illumination light.

**[0026]** The first partition wall 12 and the second partition wall 14 divide the light source blocks 10, and are made, in the present embodiment, from white polycarbonate (PC). The first partition wall 12 and the second partition wall 14 are not limited to the above-mentioned white PC, and the first partition wall 12 and the second partition wall 14 may be made from any material with a satisfying reflection coefficient.

**[0027]** In the present embodiment, the diffusion plate 15 is made of CLAREX DR-IIIC DR-60C (product name), manufactured by NITTO JUSHI KOGYO CO., LTD (thickness: 2.0 mm, haze ratio: 96%, transmission coefficient: 93%, absorption coefficient: 7%, reflection coefficient at incident angle 0°: 3.3%, reflection coefficient at incident angle 20°: 3.2%, reflection coefficient at incident angle 40°: 3.8%, reflection coefficient at incident angle 60°: 11.0%).

**[0028]** Next, the following describes a projection section of the illumination device 1 in accordance with the embodiment of the present invention, referring to Figs. 1 and (a), (b) and (c) of 3.

(a) of Fig. 3 is a plan view of the vertex of the first partition wall 12 on which is formed a projection section 20. (b) of Fig. 3 is a side view of the first partition wall 12 and of the projection section 20 shown in (a) of Fig. 3. (c) of Fig. 3 is a perspective view of the vertex of the first partition wall 12 on which the projection section 20 shown in (a) of Fig. 3 is formed.

**[0029]** As shown in (b) and (c) of Fig. 3, the projection section 20 has a triangle cross section along a direction (extension direction) in which the first partition wall 12 is extended. Because a plurality of projection sections are formed on the upper face of the vertex of the first partition wall 12, the vertex of the first partition wall 12 has a saw-toothed shape with a succession of protrusions and recesses. The projection element 20 according to the present embodiment is made from a material identical to that of the first partition wall 12, and is formed by incising the upper face of the vertex of the first partition wall 12, after the formation of the first partition wall 12.

**[0030]** With the present embodiment, the projection element 20 is formed by making vertical incisions on the first partition wall 12. The incisions are formed by incising the upper face of the vertex of the first partition wall 12 at an oblique angle of 45° vertically with respect to the

extension direction of the first partition wall 12. Further, in the present embodiment, the height in the vertical direction of the projection section 20 with regard to the upper face of the vertex of the first partition wall 12 is 1 mm, and the pitch of the extension of the first partition wall 12, that is the interval between the respective summit of two adjoining triangles, is 1 mm.

**[0031]** The light emitted from the LEDs 11 of the light source block 10 as shown in Fig. 1 is reflected on a side face of the first partition wall 12 and on the upper face of the vertex of the first partition wall 12. The light reflected therefrom is then irradiated onto the diffusion plate 15 and is finally projected towards the exterior from the diffusion plate 15.

**[0032]** As can be understood from Fig. 1, light from each RGB LED to a vertex of the first partition wall 12 takes a different path (light path). It is considered that this difference of the light paths is the cause of the color irregularity. In other words, when a light emitted by each of the LEDs 11R, the LEDs 11G and the LED 11B reaches the upper face of the vertex of the first partition wall 12, the light is reflected at different angles depending on the wavelength and is irradiated to the neighboring diffusion plate 15 at the different angles. To put it differently, the light from each LEDs 11R, LEDs 11G and LED 11B takes a different light path, and therefore the light from each LEDs 11R, LEDs 11G and LED 11B irradiates a different area.

**[0033]** As a result, when turning on one of adjoining light source blocks 10 while turning off the other, the light from the turned-on light source block 10 is irradiated on the neighboring diffusion plate 15 and thereby the differences between the light paths are reflected on the neighboring diffusion plate 15, in the case that the projection element is not provided on the upper face of the vertex of the first partition wall 12, in other words in the case that the upper face of the vertex of the first partition wall 12 is flat. The difference in the light path is, as a result, perceived by human eye as a colored contour (color irregularity).

**[0034]** In the present embodiment, the projection section 20 is provided on the upper face of the vertex of the first partition wall 12. In this case, when the light emitted respectively from the LEDs 11R, the LEDs 11G and the LED 11B reaches the projection section 20, the light is reflected by the saw-toothed shape formed by the succession of protrusions and recesses of a plurality of projection elements 20. Then, the reflected light is again reflected, at a different angle, by the adjoining projection section 20.

**[0035]** In other words, the respective light emitted by the LEDs 11R, the LEDs 11G and the LED 11B changes angle due to the saw-toothed shape formed by the succession of protrusions and recesses of the plurality of projection elements 20, and because the reflection is repeated several times, the light is diffused. Then, the diffused light is irradiated by the diffusion plate 15. As a result, it is possible to gradate the color irregularity. In

other words, it is possible to reduce the color irregularity.

**[0036]** Because the light is diffused by the shape formed by the projection element 20, a colored contour shaped identically to the plane surface of the projection section 20 (see (a) of Fig. 3) is irradiated on the diffusion plate 15. However, due to fine pitches of the protrusions and recesses of the projection sections 20 and to the above-mentioned gradation effect, the colored contour of the plane surface of the projection section 20 is hardly visible to the human eye.

**[0037]** While it is possible to effectively reduce the color irregularity when the pitches of the protrusions and recesses of the projection section 20 are for example 1 mm, the color irregularity reduction effect increases with pitches finer than 1 mm. Accordingly, finer pitches of the protrusions and recesses of the projection section 20 are preferable.

**[0038]** By providing the projection section 20 on the upper face of the vertex of the first partition wall 12 in this way, the color irregularity irradiated on the diffusion plate 15 when one of adjoining light source blocks 10 is turned on while the other is turned off can be reduced, compared to a configuration in which the projection element 20 is not provided.

**[0039]** The present invention is not limited to the present embodiment in which, as described above, the projection section 20 has a triangle cross section along the extension direction of the first partition wall 12. The present invention may have any configuration in which a plurality of projection sections 20 is formed along the extension direction of the first partition wall, and the projection section 20 has a surface along the extension direction of the first partition wall 12. For example, it is also acceptable that faces substantially vertical with respect to the extension direction of the partition wall 12 be repeatedly formed so as to be adjoining to each other in the extension direction. That is, it is acceptable that the first partition wall 12 have a quadrilateral cross section along its extension direction.

**[0040]** Further, it is possible to use the illumination device 1 according to the present embodiment as a backlight of a liquid crystal display device. The illumination device 1 according to the present embodiment is able to control individually the turning-on and turning-off of each light source block 10. Because of this, in the display screen image of the liquid crystal display device, it is possible to control the luminance to be at a high level in the light source block 10 corresponding to the display area in which a relatively bright image is being displayed, and to control the luminance to be at a low level in the light source block 10 corresponding to the display area in which a relatively dark image is being displayed. It is thus possible to provide a liquid crystal display device with a wide dynamic range.

**[0041]** In addition, with the illumination device in accordance with the present embodiment, because it is possible to prevent the color irregularity occurring between adjoining light source blocks 10 when turning on

the light in one of the light source blocks 10 and turning off the light in the other, it is possible to provide a liquid crystal display device in which a wide dynamic range is achieved but the color irregularity is inhibited.

#### Second embodiment

**[0042]** Next, a second embodiment of the present invention is described below with reference to Figs. 1 and (a) to (c) of 4. A projection element in the second embodiment has a shape different from that in the first embodiment. Because the first embodiment and the second embodiment are similar in all other respects, the explanations on the same matter will not be repeated here.

(a) of Fig. 4 is a plan view of a vertex of a first partition wall 12 on which a projection section (diffusion section) 21 is formed, in place of the projection section 20 previously described. (b) of Fig. 4 is a side view of the first partition wall 12 and of the projection section 21 shown in (a) of Fig. 4. (c) of Fig. 4 is a perspective view of the projection section 21 shown in (a) of Fig. 4.

**[0043]** As shown in (a) to (c) of Fig. 4, with the projection section 21, a face parallel to a side face of the first partition member 12 is formed with determined pitches so as to have a repeatedly bended shape, that is to say, a shape identical to that of a folding screen. Further, the projection section 21 has an upper face (the face on the side facing to the diffusion plate 15) that is flat.

**[0044]** With the present embodiment, the projection section 21 is formed by making incisions at 45° in a side face of the vertex of the first partition wall 12. Further, with the present embodiment, the projection element 21 having a repeatedly bended shape is 1 mm in length (incision depth) in a direction vertical to the side face of the first partition wall 12, and the pitches of the repeatedly bended shape, in other words the interval between two apexes of the folding screen-like shape, are 1 mm.

**[0045]** Because the projection element 21 is provided on the vertex of the first partition wall 12, as shown in Fig. 1, the light emitted respectively from the LEDs 11R, the LEDs 11G, and the LED 11B is reflected by the repeatedly bended shape of the projection element 21 when reaching the projection element 21. The reflected light is then reflected at another angle by an adjoining repeatedly bended shape.

**[0046]** In other words, the angle of the light emitted respectively by the LEDs 11R, the LEDs 11G and the LED 11B is changed by the repeatedly bended shape, and the light is diffused due to the repetition of the plurality of reflections. Then, the diffused light is irradiated by the diffusion plate 15. As a result, it is possible to gradate the color irregularity irradiated by the diffusion plate 15. In other words, it is possible to reduce the color irregularity.

**[0047]** Because the light is diffused by the repeatedly

bended shape of the projection section 21, the colored contour, which has the same shape as a planar shape of the projection element 21 (see (a) of Fig. 4), is irradiated by the neighboring diffusion plate 15. However, the bending of the projection section 21 is finely pitched, and the above-described gradation effect of color irregularity is also attained. Therefore, the colored contour having the planar shape of the projection element 21 is hardly visible to the human eye.

**[0048]** While it is possible to effectively reduce the color irregularity when a pitch of the protrusions and recesses of the projection section 20 is for example 1 mm, the color irregularity reduction effect increases with pitches finer than 1 mm. Accordingly, the bending of the projection element 21 is preferably more finely pitched.

**[0049]** By providing the projection element 21 on the upper face of the vertex of the first partition wall 12 in this way, the color irregularity irradiated on the diffusion sheet 15 when one of adjoining light source blocks 10 is turned on while the other is turned off can be reduced, compared to a configuration in which the projection element 21 is not provided.

#### Third embodiment

**[0050]** Next, a third embodiment of the present invention is described below with reference to the attached Figs. 1 and (a) to (c) of 5. A projection element in the third embodiment has a shape different from those in the first and second embodiments. Because the third embodiment is similar to the first and second embodiments in all other respects, the explanations on the same matter will not be repeated here.

(a) of Fig. 5 is a plan view of the vertex of the first partition wall 12 on which a projection section 22 is formed, in place of the projection section 20 or the projection section 21 previously described. (b) of Fig. 5 is a side view of the first partition wall 12 and of the projection section 22 shown in (a) of Fig. 5. (c) of Fig. 5 is a perspective view of the projection section 22 shown in (a) of Fig. 5.

**[0051]** As shown in (a) to (c) of Fig. 5, the projection section 22 is hemispherical. On an upper face of a vertex of a first partition wall 12, a plurality of projection sections 22 is formed along an extension direction of the first partition wall 12. The projection section 22 is formed thereby by processing the vertex of the first partition wall 12.

**[0052]** The process in order to form the projection section 22 may be, for example, the use of a metal mold to mold the projection section 22.

**[0053]** With the present embodiment, the projection elements 22 have a hemispherical shape with a 1 mm radius, and are provided on the first partition wall with 1.3 mm pitches. Adjoining projection sections 22 may be connected, or may be provided with an interval as shown in (a) of Fig. 5.

**[0054]** Because the projection section 22 is provided on the upper face of the vertex of the first partition wall 12, as shown in Fig. 1, the light respectively emitted from the LEDs 11R, the LEDs 11G and the LED 11B is reflected by the hemispherical shape of the projection element 22 when reaching the projection element 22. The diffused light is again reflected and diffused by the adjoining projection section 22. In other words, the light emitted respectively from the LEDs 11R, the LEDs 11G and the LED 11B is repeatedly reflected several times and is diffused by the hemispherical shape of the adjoining projection section 22.

**[0055]** Because the diffused light is then irradiated onto the neighboring diffusion plate 15, it is possible to gradate the color irregularity. In other words, it is possible to reduce the color irregularity.

**[0056]** At this point, because the light is diffused according to the hemispherical shape of the projection section 22, a colored contour shaped like the planar face of the projection section 22 (see (a) of Fig. 5) is irradiated on the neighboring diffusion plate 15. However, because the projection sections 22 are finely pitched, and because of the gradation effect of the color irregularity, the colored contour having the planar shape of the projection section 22 is hardly visible to the human eye.

**[0057]** In addition, because the projection section 22 is hemispherical, the colored contour overlaps and the colored contour thus overlapped is irradiated on the diffusion plate 15. As a result, it is possible to reduce the visibility of the colored contour. When using, for example, 1.3 mm pitches for the projection section 22, it is possible to efficiently reduce the color irregularity; however, pitches finer than 1.3 mm allow for a more efficient reduction of color irregularity. Accordingly, the projection element 22 is preferably more finely pitched.

**[0058]** Because a projection element 22 is provided on the upper face of the vertex of the first partition wall 12 in this way, the color irregularity irradiated on the diffusion sheet 15 when one of adjoining light source blocks 10 is turned on while the other is turned off can be reduced, compared to a configuration in which the projection element 22 is not provided.

#### Fourth embodiment

**[0059]** Next, a fourth embodiment of the present invention is described below with reference to Figs. 1 and (a) to (c) of 6. A projection element in the fourth embodiment has a shape different from those in the first, second, and third embodiments. Because the fourth embodiment is similar to the first, second and third embodiments in all other respects, the explanations on the same matter will not be repeated here.

(a) of Fig. 6 is a plan view of the vertex of the first partition wall 12 on which a projection section 23 is formed, in place of the projection section 20, the projection section 21 or the projection section 22 previously

described. (b) of Fig. 6 is a side view of the first partition wall 12 and of the projection section 23 shown in (a) of Fig. 6. (c) of Fig. 6 is a perspective view of the projection section 23 shown in (a) of Fig. 6.

**[0060]** As shown in (a) to (c) of Fig. 6, the projection section 23 is conical. On an upper face of a vertex of the first partition wall 12, a plurality of projection sections 23 is formed along an extension direction of the first partition wall 12. The projection section 23 is formed by processing the vertex of the first partition wall 12.

**[0061]** The process in order to form the projection section 23 may be, for example, the use of a metal mold to mold the projection section 23.

**[0062]** With the present embodiment, the projection element 23 comprises a conical shape with a 1 mm radius, and is provided on the first partition wall with 1.3 mm pitches. Adjoining projection sections 23 may be connected, or may be provided with intervals as shown in (a) of Fig. 6.

**[0063]** Because the projection section 23 is provided on the upper face of the vertex of the first partition wall 12, as shown in Fig. 1, the light respectively emitted from the LEDs 11R, the LEDs 11G and the LED 11B is reflected by the conical shape of the projection element 23 when reaching the projection element 23. The diffused light is again reflected and diffused by the adjoining projection section 23.

**[0064]** In other words, the light emitted respectively from the LEDs 11R, the LEDs 11G and the LED 11B is repeatedly reflected several times and is diffused by the conical shape of the adjoining projection section 23. Because the diffused light is then irradiated by the neighboring diffusion plate 15, it is possible to gradate the color irregularity. In other words, it is possible to reduce the color irregularity.

**[0065]** At this point, because the light is diffused by the conical shape of the projection section 23, a colored contour shaped like the flat face of the projection section 23 (see (a) of Fig. 6) is irradiated on the neighboring diffusion plate 15. However, because the projection section 23 is finely pitched, and because of the gradation effect of the color irregularity, the colored contour having planar shape of the projection section 23 is hardly visible to the human eye.

**[0066]** In addition, because the projection section 23 is conical, the colored contour overlaps and the overlapped colored contour is irradiated on the diffusion plate 15. As a result, it is possible to reduce the visibility of the colored contour. When using, for example, 1.3 mm pitches for the projection section 23, it is possible to efficiently reduce the color irregularity; however, pitches finer than 1.3 mm allow for a more efficient reduction of color irregularity. Accordingly, the projection element 23 is preferably finely pitched.

**[0067]** Because a projection element 23 is provided on the upper face of the vertex of the first partition wall 12

in this way, the color irregularity irradiated on the diffusion sheet 15 when one of adjoining light source blocks 10 is turned on while the other is turned off can be reduced, compared to a configuration in which the projection element 23 is not provided.

#### Fifth embodiment

**[0068]** Next, a fifth embodiment of the present invention is described below with reference to Figs. 1 and (a) to (c) of 7. The fifth embodiment differs from the first, second, third, and fourth embodiments in that a diffusion section is provided in place of the projection section in the fifth embodiment. Because the fifth embodiment is similar to the first, second, third, and fourth embodiments in all other respects, the explanations on the same matter will not be repeated here.

(a) of Fig. 7 is a plan view of a vertex of a first partition wall 12 on which a diffusion section 24 is formed, in place of the projection section 20, the projection section 21, the projection section 22 or the projection section 23 previously described. (b) of Fig. 7 is a side view of the first partition wall 12 and of the projection section 24 shown in (a) of Fig. 7. (c) of Fig. 7 is a perspective view of the projection section 24 shown in (a) of Fig. 7.

**[0069]** As shown in (a) to (c) of Fig. 7, the diffusion section 24 is formed on the vertex of the first partition wall 12. The diffusion section 24 is made from a material (diffusion material) allowing a better diffusion of light than the material used for the first partition wall 12. For example, the diffusion material may be foamed thereby introducing air particles therein.

**[0070]** In the present embodiment, the diffusion element 24 is formed by forming an upper portion of the first partition wall 12 with the diffusion material. The upper portion is 1 to 2 mm deep from the upper face of the vertex in the present embodiment. Further, the vertex of the first partition wall 12 and the diffusion material are for example bonded with an adhesive agent. The adhesive agent is not limited particularly, and any widely used bonding agent allowing the bonding of the vertex of the first partition wall 12 and the diffusion element 24 may be used with the present embodiment.

**[0071]** Because the diffusion section 24 is formed on the first partition wall 12, it is not necessary to perform the incision or the shaping of the resin, in contrast to the cases in which the projection sections 20 to 23 are formed.

**[0072]** Because the diffusion section 24 is provided on the upper face of the vertex of the first partition wall 12, as shown in Fig. 1, the light respectively emitted from the LED 11 R, the LED 11 G and the LED 11B is reflected by the surface of the diffusion element 24 when reaching the diffusion element 24. Because the diffused light is then irradiated by the neighboring diffusion plate 15, it is

possible to gradate the color irregularity. In other words, it is possible to reduce the color irregularity.

**[0073]** At this point, because the light is diffused by the surface of the diffusion section 24, a colored contour having a planar shape of the diffusion section 24 (see (a) of Fig. 7) is irradiated on the neighboring diffusion plate 15. However, because the diffusion section 24 is made from a diffusion material, and because of the gradation effect of the color irregularity, the colored contour on the flat face of the projection section 23 is hardly visible to the human eye. Because a diffusion element 24 is provided on the upper face of the vertex of the first partition wall 12 in this way, the color irregularity irradiated on the diffusion sheet 15 when one of adjoining light source blocks 10 is turned on while the other is turned off can be reduced, compared to a configuration in which the diffusion element 24 is not provided.

**[0074]** The invention being thus described, it will be obvious that the same way may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

**[0075]** As described above, the illumination device in accordance with the present invention comprises a plurality of illumination areas defined by partition walls, and a light source in each illumination area, and is capable of adjusting luminance of each illumination area independently. The illumination device further comprises a diffusion section on a vertex of each partition wall, for diffusing the light.

**[0076]** With this configuration, the light emitted from the light source of the illumination area is diffused by the diffusion section provided on the vertex of the partition wall. As a result, it is possible to inhibit the luminance irregularities occurring when adjusting the luminance for each adjoining illumination area.

**[0077]** Further, because the diffusion section is provided on the vertex of the partition wall, it is not necessary to increase the width of the partition wall when adding the diffusion section. Further, because the diffusion section is provided on the vertex of the partition wall, it is possible to provide a path of the light (light path) emitted from each of the adjoining illumination areas so as to make it symmetric to the vertex of the partition wall. As a result, compared to when the diffusion section is not provided on the vertex of the partition wall, it is possible to provide the diffusion section efficiently and to inhibit efficiently the luminance irregularities occurring when adjusting the luminance for each adjoining illumination area.

**[0078]** In the illumination device in accordance with the present invention, the partition walls include first partition walls defining the plurality of illumination areas and second partition walls surrounding the plurality of illumination areas. The illumination device in accordance with the present invention further comprises a transparent member for transmitting the light from the light source, wherein

the transparent member is supported by the second partition wall, a combined height of the first partition wall and of the diffusion section being lower than a height of the second partition wall.

**[0079]** With this configuration, a height of the transparent member is determined based on the height of the second partition wall. As a result, a space is provided between the transparent member and the diffusion section. In other words, it is possible to determine a size of this space within the range between the height of the transparent member (determined based on the height of the second partition member) and the combined height of the first partition wall and the diffusion section.

**[0080]** When the plurality of illumination areas emit light at the same luminance, the light is mixed in the space. In other words, the light emitted by the plurality of illumination areas is mixed within the range between the height of the transparent member (determined based on the height of the second partition member) and the combined height of the first partition wall and the diffusion section. As a result, it is possible to prevent the luminance in the vicinity of the projection section from becoming dark. Accordingly, it is possible to achieve a uniform irradiated light while inhibiting luminance irregularity.

**[0081]** In the illumination device in accordance with the present invention, the light sources preferably include a plurality of light sources having different wavelengths. With this configuration, because the light is emitted from a plurality of light sources having various wavelengths, it is possible to widen the luminance ratio of the light between adjoining illumination areas. In other words, it is possible to expand the dynamic range of the adjoining light sources.

**[0082]** In the illumination device in accordance with the present invention, each diffusion section includes a face facing along an extension of the first partition walls, so that the faces facing the extension of the first partition walls are provided in plurality along the extension of the first partition walls. With this configuration, the light emitted from the light source is reflected from the plurality of faces formed along the extension direction of the first partition wall. Then, the reflected light is reflected again by the adjoining faces formed in the extension direction of the first partition wall. In other words, because the light emitted from the light source is repeatedly reflected by the faces adjoining each other and is thus diffused, it is possible to gradate the color irregularity. Accordingly, it is possible to inhibit the color irregularity.

**[0083]** The light emitted by the light source is reflected through the shape formed by the plurality of faces along the extension direction of the first partition wall. This causes a color irregularity, having the same shape as the planar shapes formed along the extension direction of the first partition wall. However, because the faces are formed adjoining and because of the above gradation effect of the color irregularity, the color irregularity shaped like the previously described plane shape is hardly visible to the human eye.

**[0084]** In the illumination device in accordance with the present invention, the diffusion section comprises a plurality of projection sections having a triangular cross section in the extension direction of the first partition walls. Alternatively, each diffusion section has a face having a repeatedly bended shape, along a side face of the first partition walls.

**[0085]** With this configuration, the light emitted from the light source is reflected by the triangular shape of the section of the projection sections in the extension of the partition wall, or alternatively by the repeatedly bended shape. Then, the reflected light changes angle and is reflected again due to a projection section adjoining to the projection section, or alternatively due to a bended shape adjoining to the bended shape.

**[0086]** In other words, because the light emitted from the light source is repeatedly reflected, and thus diffused, due to a projection section adjoining to the projection section or alternatively due to the repeatedly bended shape, it is possible to gradate the color irregularity. Accordingly, it is possible to inhibit the color irregularity.

**[0087]** Further, due to the triangular shape of the section of the projection section along the extension direction of the partition wall, or alternatively due to the repeatedly bended shape, the reflected light changes angle when reflected. Accordingly, the diffusion angle of the light becomes wider. As a result, it is possible to further inhibit the color irregularity.

**[0088]** In the illumination device in accordance with the present invention, the diffusion section comprises a plurality of projection sections, each of which is hemispherical. Alternatively, the diffusion section comprises a plurality of projection sections, each of which is conical.

**[0089]** With this configuration, the light emitted from the light source is reflected by the hemispherical shape or the conical shape of the projection section. Then, the reflected light changes angle due to a projection section adjoining to the projection section, and is reflected again.

**[0090]** In other words, because the light emitted from the light source is reflected repeatedly and thus diffused due to the fact that the projection sections are formed adjoining, it is possible to gradate the color irregularity. Accordingly, it is possible to inhibit the color irregularity.

**[0091]** Further, because the projection section is hemispherical or conical, the light is reflected at a determined angle due to a curve of the hemispherical or conical shape. Then, due to a projection section adjoining to the projection section, the reflected light is reflected again at a determined angle. With this configuration, because of the hemispherical or conical shape, the light overlaps and is diffused.

**[0092]** As a result, it is at the same time possible to efficiently diffuse the light emitted from the light source and possible to overlap and gradate the color irregularities. Accordingly, it is possible to control the color irregularities in an even more efficient way.

**[0093]** In the illumination device in accordance with the present invention, the diffusion section is preferably

made from a diffusion material diffusing light.

**[0094]** With this configuration, the light emitted from the light sources is diffused by the vertex of the partition wall, made from the diffusing material. As a result, it is possible to inhibit the luminance irregularity occurring when adjusting the luminance of each adjoining illumination area.

**[0095]** A liquid crystal display device in accordance with the present invention is provided with the illumination device. With this configuration, it is possible to provide a liquid crystal display device in which luminance irregularity and color irregularity are inhibited but a wide dynamic range is attained.

**[0096]** As described above, the illumination device in accordance with the present invention comprises a plurality of illumination areas defined by partition walls, and a light source in each illumination area, and is capable of adjusting luminance of each illumination area independently. The illumination device further comprises a diffusion section on a vertex of each partition wall, for diffusing the light.

**[0097]** As a result, it is possible to inhibit the luminance irregularity occurring when adjusting the luminance of each adjoining light source.

#### Industrial Applicability

**[0098]** Because the present invention makes it possible to inhibit the light irregularity in the illumination area occurring when adjusting the respective luminance of each of the plurality of illumination areas, it can be widely applied to any type of electronic device provided with a surface light source and required to have a wide dynamic range for light quantity control purposes.

#### Claims

**1.** An illumination device comprising a plurality of illumination areas defined by partition walls, and a light source in each illumination area, and being capable of adjusting luminance of each illumination area independently, the illumination device further comprising a diffusion section on a vertex of each partition wall, for diffusing the light.

**2.** The illumination device according to claim 1, comprising:

a transparent member for transmitting the light from the light source,

wherein:

the partition walls include:

a first partition wall defining the plurality of illumination areas; and

a second partition wall surrounding the plurality of illumination areas,  
the transparent member is supported by the second partition wall,  
a combined height of the first partition wall and of the diffusion section is lower than a height of the second partition wall.

**3.** The illumination device according to claim 1 or 2, wherein the light sources include a plurality of light sources having different wavelengths.

**4.** The illumination device according to any one of claims 1 to 3, wherein each diffusion section includes a face facing along an extension direction of the first partition wall, so that the faces facing the extension of the first partition wall are provided in plurality along the extension direction of the first partition wall.

**5.** The illumination device according to any one of claims 1 to 4, wherein the diffusion section comprises a plurality of projection sections having a triangular cross section in the extension direction of the first partition wall.

**6.** The illumination device according to any one of claims 1 to 4, wherein each diffusion section has a face having a repeatedly bended shape, along a side face of the first partition wall.

**7.** The illumination device according to any one of claims 1 to 4, wherein the diffusion section comprises a plurality of projection sections, each of which is hemispherical.

**8.** The illumination device according to any one of claims 1 to 4, wherein the diffusion section comprises a plurality of projection sections, each of which is conical.

**9.** The illumination device according to any one of claims 1 to 3, wherein the diffusion section is made from a diffusion material diffusing light.

**10.** A liquid crystal display device provided with an illumination device according to any one of claims 1 to 9.

FIG. 1

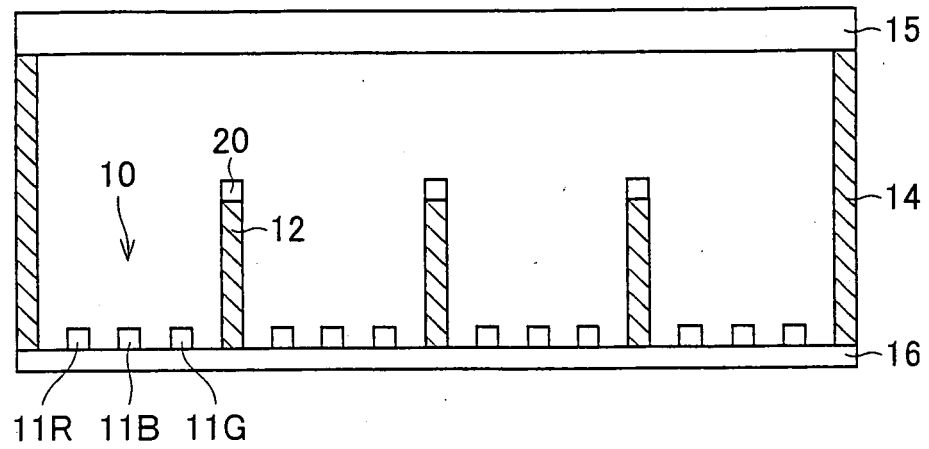


FIG. 2

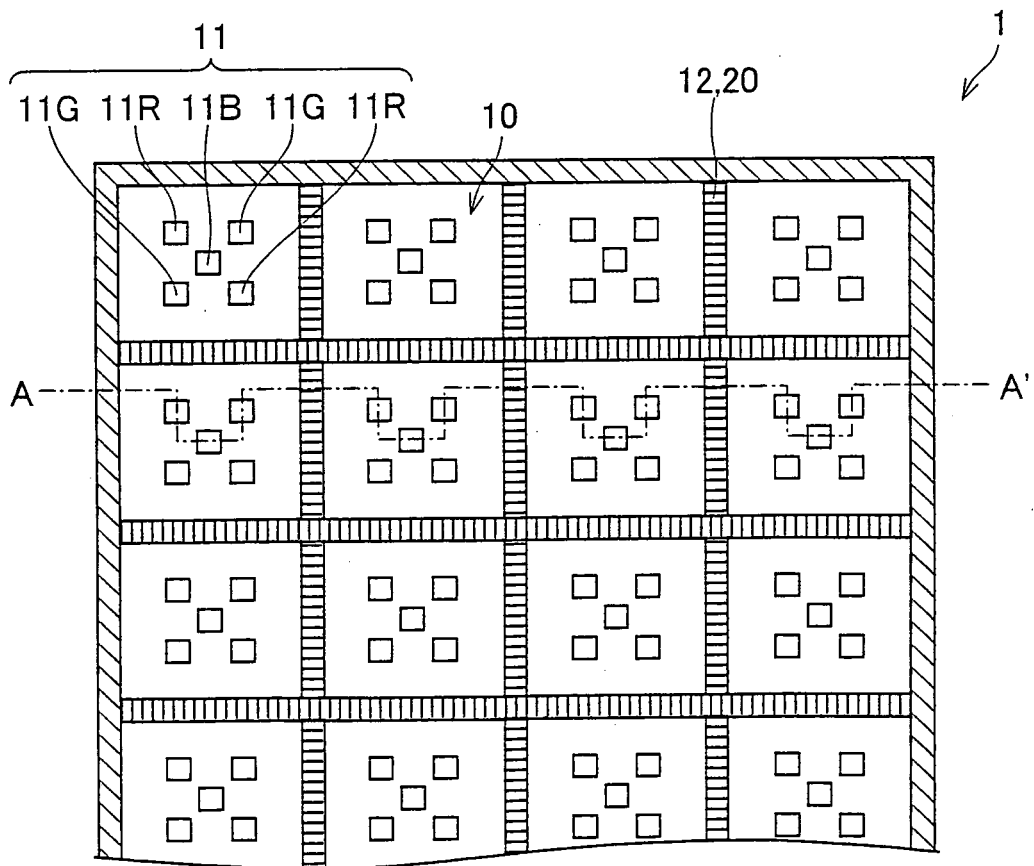


FIG. 3

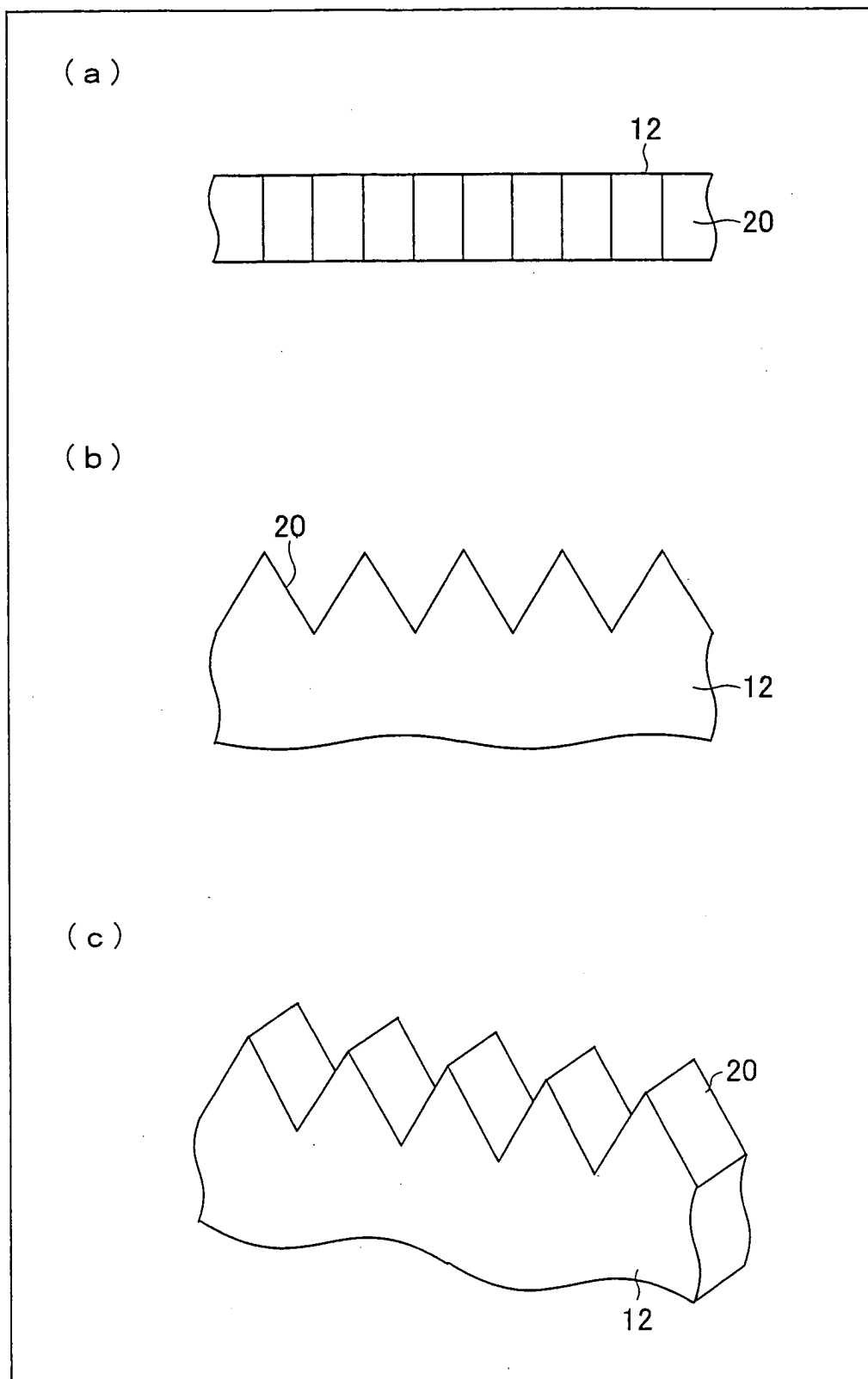


FIG. 4

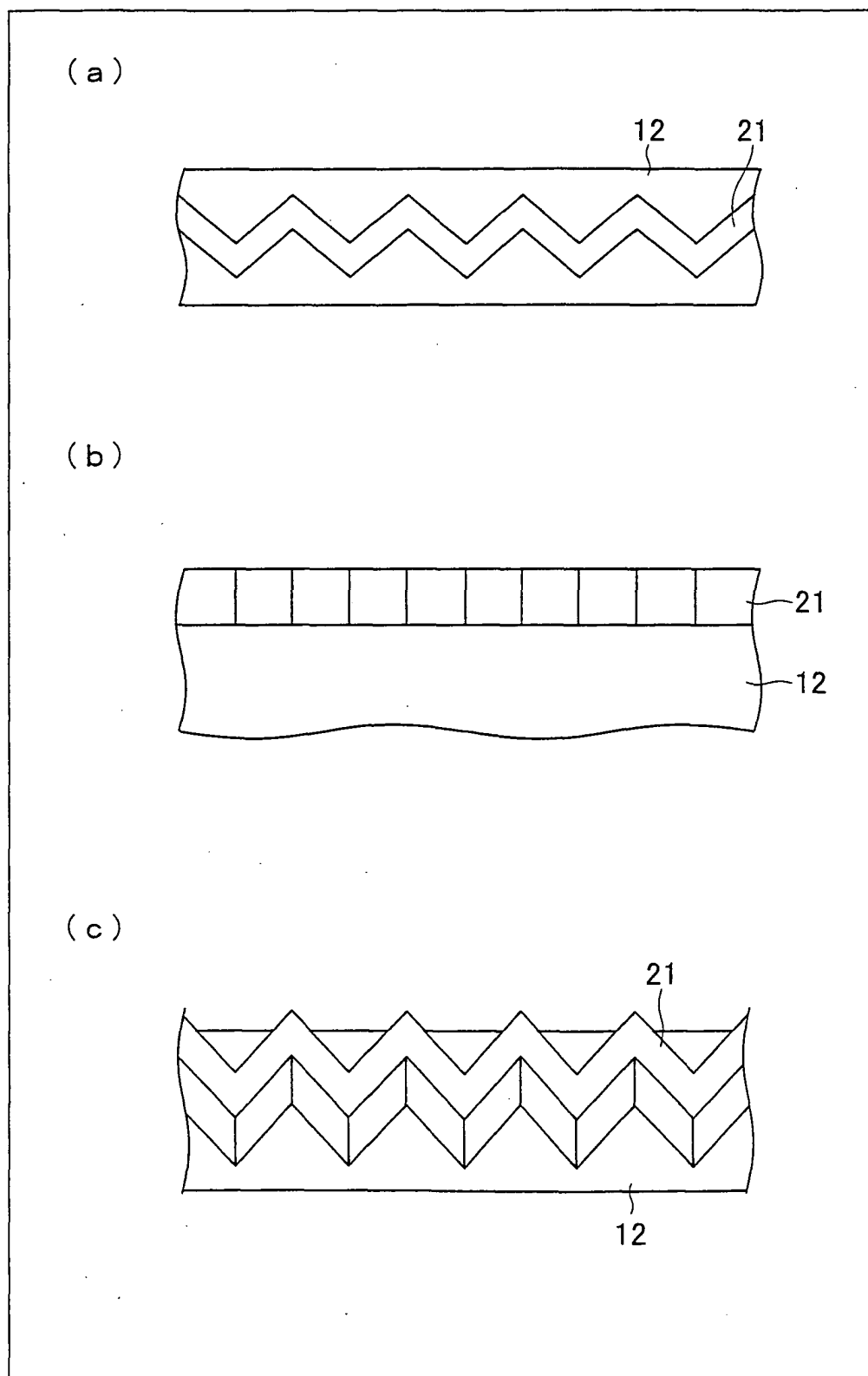


FIG. 5

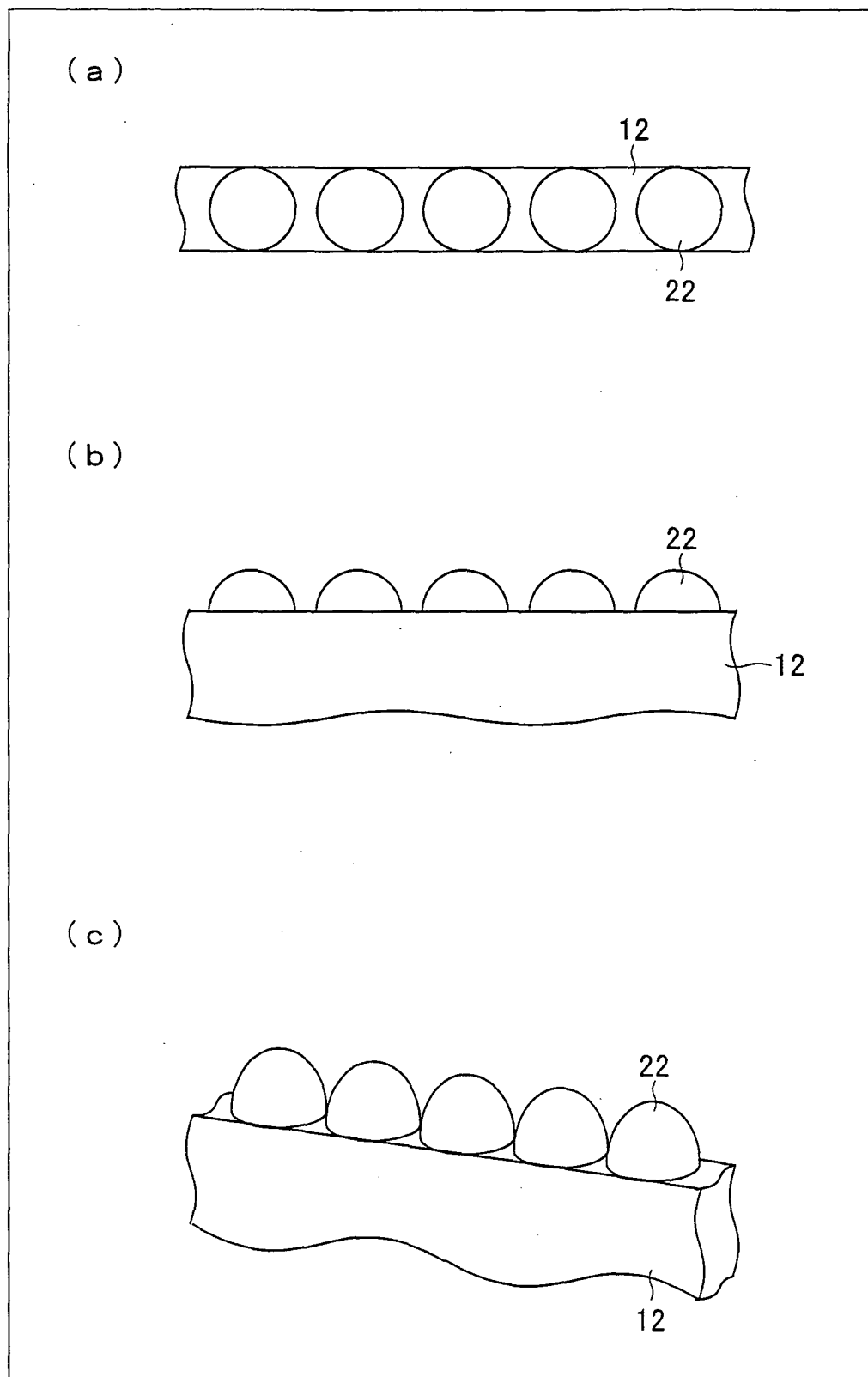


FIG. 6

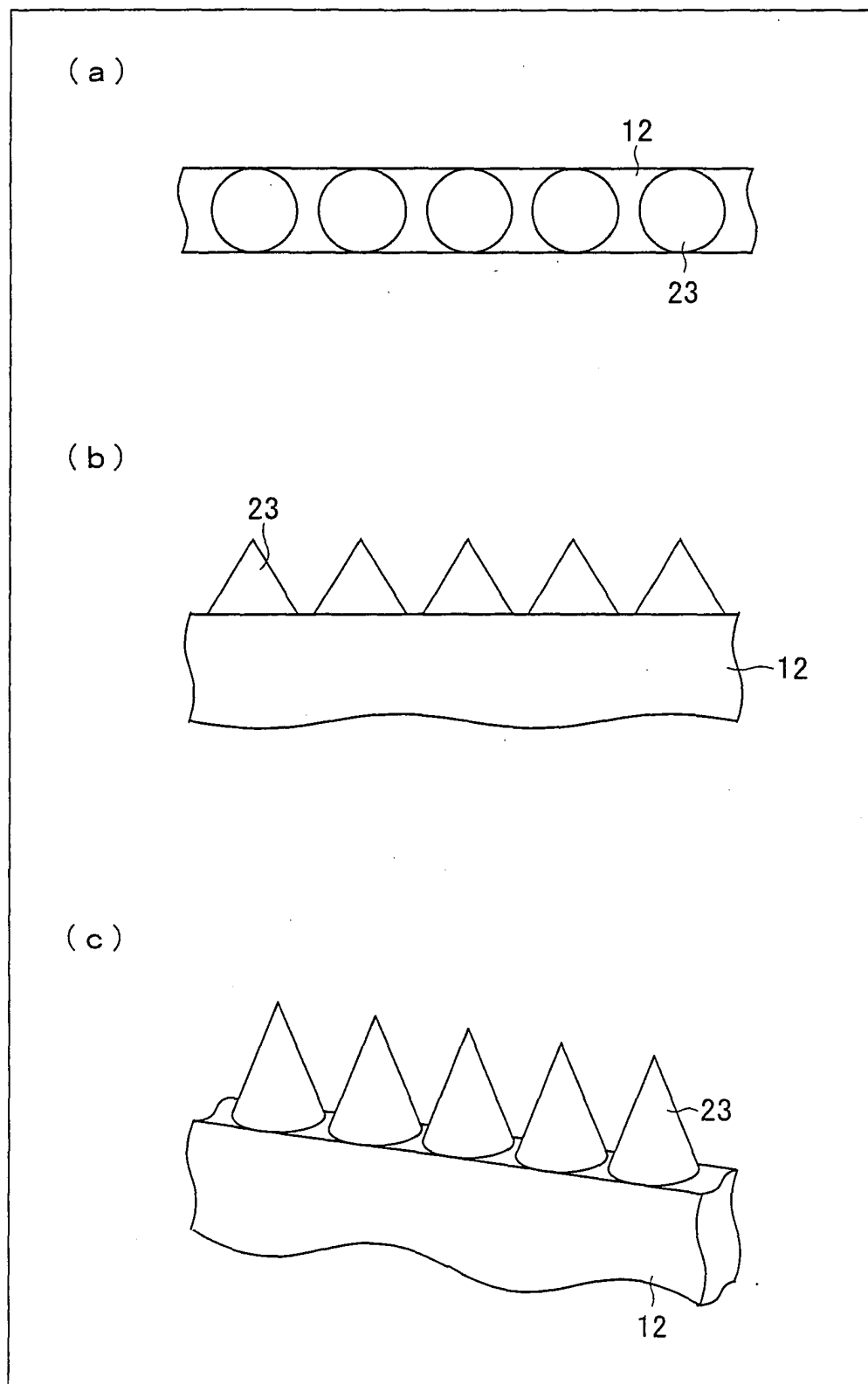


FIG. 7

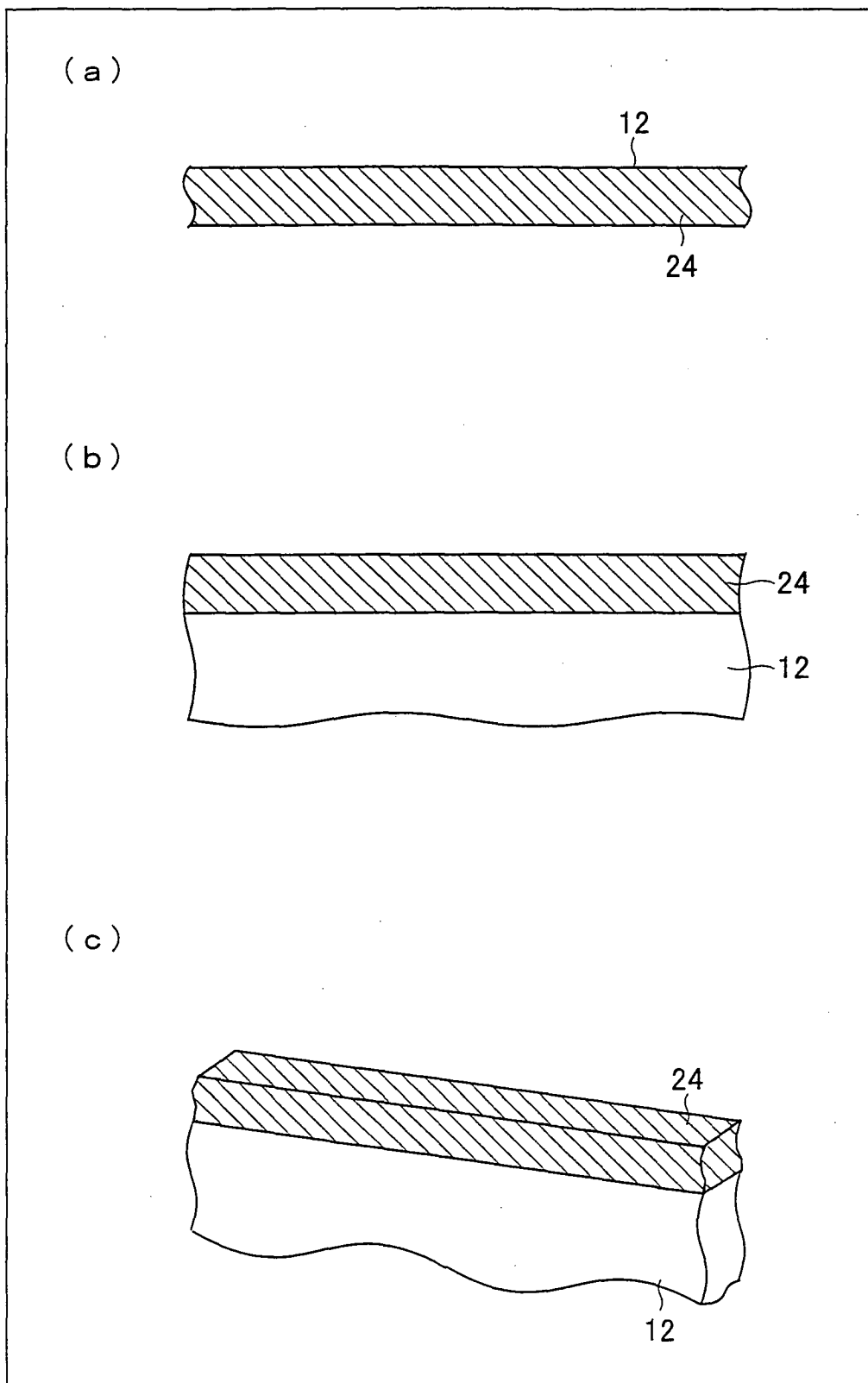
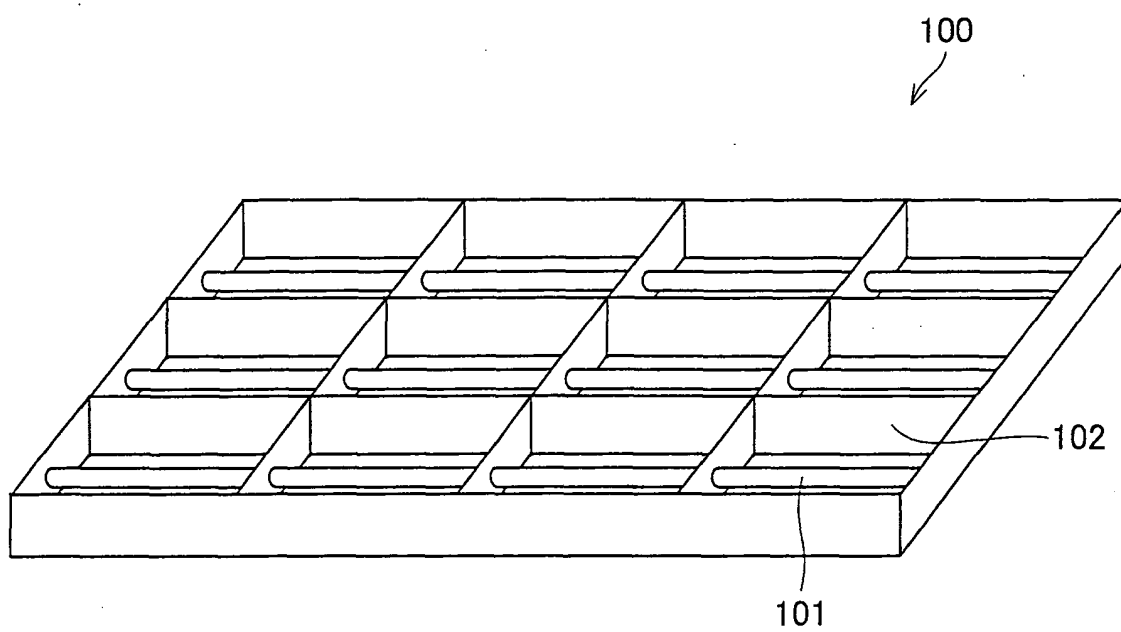


FIG. 8



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/064087

## A. CLASSIFICATION OF SUBJECT MATTER

F21S2/00(2006.01)i, F21V11/06(2006.01)i, G02F1/13357(2006.01)i,  
F21Y101/02(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F21S2/00, F21V11/06, G02F1/13357, F21Y101/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008  
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                | Relevant to claim No. |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 2007-180005 A (L.G. Philips LCD Co., Ltd.),<br>12 July, 2007 (12.07.07),<br>Full text; all drawings<br>& US 2007/70625 A1 & KR 10-2007-69499 A | 1-10                  |
| A         | JP 2007-103154 A (The Furukawa Electric Co.,<br>Ltd.),<br>19 April, 2007 (19.04.07),<br>Full text; all drawings<br>& WO 2007/040199 A             | 1-10                  |
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☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
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Date of the actual completion of the international search  
25 August, 2008 (25.08.08)

Date of mailing of the international search report  
02 September, 2008 (02.09.08)

Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/064087

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                 | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 2007-101862 A (The Furukawa Electric Co., Ltd.),<br>19 April, 2007 (19.04.07),<br>Full text; all drawings<br>& WO 2007/040198 A | 1-10                  |
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| A         | JP 2003-36719 A (Akira TANAKA),<br>07 February, 2003 (07.02.03),<br>Full text; all drawings<br>(Family: none)                      | 1-10                  |

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

**REFERENCES CITED IN THE DESCRIPTION**

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